Geographic and socioeconomic variations in adolescent toothbrushing: A multilevel cross-sectional study of 15 year olds in Scotland

(Accepted for publication in Journal of Public Health)

Levin KA[a,b], Nicholls N[c], Macdonald S[c], Dundas R[c], Douglas GVA[d]

[a] NHSGGC Public Health Directorate West House, Gartnavel Royal Hospital, 1055 Great Western Road

G12 0HX; email:katyannlevin@gmail.com

[b] Ludwig Boltzmann Institute, Untere Donaustraße 47, 3rd Floor

A-1020 Vienna, Austria

[c]MRC/CSO Social and Public Health Sciences Unit, 200 Renfield Street, Glasgow G2 3QB

email: natalie.nicholls@glasgow.ac.uk; scott.macdonald@glasgow.ac.uk; ruth.dundas@glasgow.ac.uk

[d] Leeds Dental Institute, University of Leeds, Leeds LS2 9LU, UK; email: g.v.a.douglas@leeds.ac.uk

Abstract word count (180)

Main Text count (2,999)

Abstract

Background This study examined urban-rural and socioeconomic differences in adolescent toothbrushing.

Methods The data were modelled using logistic multilevel modelling and the Markov Chain Monte Carlo (MCMC) method of estimation. Twice-a-day toothbrushing was regressed upon age, family affluence, family structure, school type, area-level deprivation and rurality, for boys and girls separately.

Results Boys' toothbrushing was associated with area- level deprivation but not rurality. Variance at the school level remained significant in the final model for boys' toothbrushing. The association between toothbrushing and area-level deprivation was particularly strong for girls, after adjustment for individuals' family affluence and type of school attended. Rurality too was independently significant with lower odds of brushing teeth in accessible rural areas.

Conclusions The findings are at odds with the results of a previous study which showed, lower caries prevalence among children living in rural Scotland. A further study concluded that adolescents have a better diet in rural Scotland. In total, these studies highlight the need for an examination into the relative importance of diet and oral health on caries, as increases are observed in population obesity and consumption of sugars.

Keywords: urban-rural, toothbrushing, adolescent

Introduction

Toothbrushing with fluoride toothpaste is believed to be the single behaviour most strongly associated with dental caries.[1] It is recommended that children's teeth are brushed at least twice daily with fluoride toothpaste, from the moment the first tooth appears, to reduce levels of caries and gum disease.[2] Previous studies have shown strong association between socioeconomic status (SES) and child oral health and oral health behaviour. Family affluence, parental occupation and family structure, have shown associations with adolescent toothbrushing with poorer results those with lower SES.[3,4] Furthermore, area-level deprivation is associated with prevalence and extent of childhood dental caries,[5,6] Importantly, Poulton et al[7] found that SES in childhood was associated with poor oral health in adulthood even after adjustment for adult SES, suggesting SES during childhood to have a profound effect on oral health.

Historically, Scotland's children have had relatively poor oral health compared to other countries in the UK and North Western Europe.[8] This was thought to be largely due to a diet high in sugar and poor oral health care including infrequent toothbrushing. Following a government consultation highlighting the need for significant improvement, national targets were introduced directed at early years' oral health[9] and several initiatives, collectively known as Childsmile,[10] designed to improve the oral health of children and young people in Scotland, are currently under way. These include supervised fluoride toothbrushing schemes for younger children and oral health promotion programmes in secondary schools.[11] More recent statistics show improvements in oral health across the child population.[12,13] However, some groups of society continue to have particularly high prevalence of caries and low rates of twice-a-day toothbrushing.

Scotland has a very disparate geography. Most of the population of Scotland resides in the central belt which includes the two largest cities, Glasgow and Edinburgh, and several other large towns. The Highlands and Islands, home to 7 % of the Scottish population, makes up over 60% of Scottish landmass, with a resulting sparse population density of 8 people per square kilometre in remote rural areas. These large differences in geography make the study of urban-rural differences in health in Scotland particularly interesting. Previous research, largely focussed on adult health, has shown less favourable outcomes in remote rural Scotland.[14-17] Geographic differences in health outcomes are thought to be due to several possible factors. Specific to oral health are differences in the number of dental service registrations among the child population[18] as well as differences in remuneration method and dental specialisms[19]and access to services due to the physical environment.[20] In rural Scotland there is a lower proportion of children registered to a dental practice and a higher proportion of salaried (as opposed to publicly funded) dental practitioners.

In a previous study, Levin et al,[21] found that children living in rural areas had better dental health than those living in urban Scotland, even after adjustment for deprivation. It was concluded that in rural Scotland either: 1. children brushed their teeth with fluoride more regularly, or 2. children had better eating behaviour, or 3. access to or provision of dental health services was better. Accordingly, the current study set out to examine the first theory. As rural areas of Scotland are characterised by lower levels of deprivation,[22] studying geographic inequalities requires adjustment of area-level deprivation. A second aim of the paper was to consider socioeconomic inequalities in toothbrushing at the individual, school and area-level. We hypothesise that the analyses will show higher prevalence of toothbrushing among young people of higher SES and in rural areas, particularly accessible rural areas.

Methods

Study Design

This paper uses Scottish data from the Health Behaviour in School-aged Children (HBSC) Scotland survey collected between January and March of 2010. The population was stratified by education authority and school type, and a nationally representative sample was selected using systematic random sampling. Pupils in Secondary 4 (S4), aged on average 15.5 years, received questionnaires in school using passive parental consent. The questionnaire was completed anonymously in class under teacher supervision. The research protocol was approved by the University of Edinburgh’s School of Education Ethics Committee.

The 2010 HBSC Scotland survey sample of S4 pupils was boosted in rural areas to be representative of both urban and rural Scotland (Table 1). The boosted sample of classes was selected randomly within each rurality classification, assigned to schools by their postcode, with the aim of achieving a minimum of 300 children within each rurality classification, to give 95% confidence intervals of ±6% around a proportion of 65% and a design factor of 1.2.

Outcome variables

The survey asked young people how often they brush their teeth. Responses were 'More than once a day, Once a day, At least once a week but not daily, Less than once a week, Never'. The data were re-coded to give a dichotomous variable, 'brush teeth twice a day or more'/'do not brush teeth twice a day'.

Explanatory variables

Young people's age and sex were included in analysis. School type (state or independent) was also included. The Family Affluence Scale (FAS) was calculated using items on car ownership, own bedroom, family holidays and computer ownership.[23] The items were combined using categorical principal components analysis to produce tertiles of low, medium and high FAS. Family structure was also included as this may be a proxy for SES and is known to be related to both FAS and toothbrushing.[5] Survey respondents were coded as living with both parents/ a single parent/step family/'other'.

The Scottish Index of Multiple Deprivation (SIMD) was included as an indicator of deprivation at the 'data zone' small-area level.[24] This was assigned to individual child's home postcode. The results presented were for relative deprivation using quintiles, as recommended[25]. Rurality was included as a categorical variable, as defined by the 2008 Scottish Household Survey urban-rural classification.[26]

A further set of explanatory variables, found previously to be associated with adolescent toothbrushing and possible confounders of its association with rurality,[4] was included in the final model. The effect on existing variables in the model was noted. These variables were grouped under the subheadings: family demographics (ethnicity, family size, having a second home), SES/wealth (Family SES, joblessness), family relationships (contact with parents, perceived parenting, relationship with parents, relationship with elder brother, relationship with elder sister) and mealtime routines (breakfast consumption frequency, family meal frequency, food poverty). For more information on these variables please see Levin and Currie.[4]

Data Imputation

Of the 3577 young people who responded to the survey (4211 were surveyed), 885 (25%) had missing postcode information, 54% boys and 46% girls. This meant 25% of cases could not be assigned rurality or SIMD indicators. Among those who did provide postcode information, twice-a-day toothbrushing was marginally more prevalent; 75% compared with 71% of those with missing data. Although there did not appear to be response bias by affluence, to avoid exclusion and maximise the power of the study, multiple imputation by chained equation (MICE) was carried out in SPSS version 19.0, to impute missing deprivation and rurality information.[27] In addition to predictor and outcome variables, we included in the imputation model the following associated measures: school, perceived safety of local area, good places to go locally, able to trust people locally, litter in local neighbourhood, time taken to get to school, method of travel to school, reported physical activity and education authority. Twenty imputed datasets were generated as recommended.[28]

Statistical analysis

As there are known gender differences in adolescent twice-a-day toothbrushing and associated factors,[4] the dataset was stratified by gender and treated as two separate datasets, one for girls and one for boys. Preliminary analyses described the data, presenting frequencies for each variable for boys and girls, using the statistical software SPSS, version 15.0 Complex Samples package. This took account of the clustered nature of the data; children clustered within schools, clustered within stratum, defined by Education Authority. Multivariable multilevel models adjusting for all explanatory variables were run in in MLwiN,[29] using the Markov Chain Monte Carlo (MCMC) method of estimation, and Odds Ratios and 95% Confidence Intervals were calculated. Fixed and random parameter estimates were tabulated. Estimates reported in the results are based on a chain of length of 50,000 following a burn-in of 15,000. The Deviance Information Criterion (DIC) was used as a measure of model fit with a lower value of the DIC being favoured.[30] Models were then run for each of the imputed datasets, and were combined using Rubin's Rule.[31] Results for complete-case and imputed datasets were compared and discussed.

Moran's I statistics were calculated using R,[32] and the package GWmodel,[33] for the complete-case models to measure spatial autocorrelation, as recommended.[34] For comparison of 20 nearest neighbours, I= 0.20 (expected value -0.0008, variance 0.00007) for boys and

I=0.17 for girls (expected value -0.0007, variance 0.00006), p<0.001 for both. This indicates significant autocorrelation of the residuals, however when the complete-case datasets were modelled adjusting for autocorrelation using spatial modelling techniques, the parameter estimates saw little change, and this did not affect the overall conclusions.

A further final stage of modelling adjusted for familial variables detailed in Levin and Currie.[4] Again, this did not affect the overall conclusions of the paper, serving only to strengthen the findings. All results not presented are available from the authors on request.

Results

Girls were more likely to brush their teeth than boys (83% compared with 65%, p<0.001) (Table 2). Boys and girls of high FAS were more likely to brush their teeth twice a day (p=0.036 and p<0.001 respectively). Similarly, those living with both parents were more likely to brush their teeth twice a day, while girls living in single parent families and boys living in single parent or step families were less likely to do so. Accessible rural areas had significantly lower prevalence of girls' toothbrushing when compared with remote rural (p=0.024) and urban areas (p=0.043). Prevalence of toothbrushing rose with area-level affluence for both boys and girls, with greatest toothbrushing prevalence among those living in the least deprived SIMD quintile.

When the data were modelled, boys' toothbrushing was associated with family structure and area- level deprivation only (Table 3). Boys living in a family structure other than the traditional 2-parent family had low odds of brushing teeth twice a day, although this varied by area-level deprivation, so that a boy living in a step family but in an area classified as SIMD 5 had higher odds (OR=1.10) of brushing teeth twice a day than a boy living with both parents but in SIMD 1. After adjustment for all variables, variance at the school level remained significant for boys' toothbrushing (under a one-sided t-test). Girls' toothbrushing was associated with FAS, family structure, area-level deprivation and rurality, with lower odds of brushing teeth in accessible rural areas. Unexplained variance was not significant at the school or education authority level. Interactions between rurality and SIMD or FAS were not significant for boys' or girls' toothbrushing.

When further explanatory variables were included in the model (not shown), this did not affect the significance of the variables or school-level variance listed in Table 4, with only marginal differences in effect sizes. Of the variables included only sharing a family meal and regular breakfast consumption were additionally significant predictors of boys' toothbrushing and only perceived parenting and regular breakfast consumption were additional predictors for girls' toothbrushing.

The imputed datasets were then modelled and combined to give the estimates shown in Table 4. The only differences between these and the models for complete-case analysis were that toothbrushing was associated with age for both boys and girls, with greater odds for older boys and lower odds for older girls. The relationship between boys' toothbrushing and family structure and SIMD was more pronounced in the final models based on imputed data, but this aside, results for both complete-case and imputed datasets were very similar.

Discussion

Main findings of the study

This study finds that girls' twice-a-day toothbrushing is less prevalent in accessible rural areas, when compared with urban areas, and that this difference persists after adjustment for both FAS and area-level deprivation. A further finding of this paper is that twice-a-day toothbrushing is strongly patterned by area-level deprivation, even after adjustment for individual affluence. There are known difficulties in distinguishing individual and area-level effects.[35,36] The affluence measure used here may not distinguish SES appropriately, so that what appear to be area-level effects may be at the individual level. Nevertheless, identifying at-risk groups by area is relevant for many initiatives.

What is already known on this topic

A previous examination of 5 year-olds' caries experience ($d_3$mft) found that children from accessible rural Scotland had lower prevalence of caries and a lower count of teeth affected by caries.[21] Better oral hygiene in rural areas was hypothesised as a possible explanation for better oral health in rural areas. Additionally, a study of geographic differences in adolescent food consumption showed lower prevalence of sweets and crisps consumption in rural areas.[37] A second explanation might therefore be related to differences in diet.

The Childsmile programme has sought to improve the oral health of children in Scotland and tackle socioeconomic inequalities. Interventions include provision of a child dental service within the education system, education of care-givers through oral health guidance leaflets disseminated in maternity wards and followed up at various stages of the child's early years, as well as dissemination of dental packs (toothbrush and fluoride toothpaste) and feeder cups, use of fluoride varnish and sealants. The initiative has additionally provided a range of resources for practitioners. Childsmile originated in 2006 as an initiative directed at nurseries in more deprived areas in Scotland but has more recently been rolled out nationally and extended into schools and other community settings.

What this study adds

The findings of this study, in combination with the findings of previous studies of geographic differences in caries[21] and diet,[37] suggests one of three things. Firstly, it may be that the oral health of 5 year olds in 2008 at the small-area level is not correlated to oral health behaviour of 15 year olds in 2010. Secondly, the children were not asked whether they brushed their teeth with fluoride toothpaste, or what other preventative measures they had undertaken, eg visits to the dentist, fluoride varnishing etc. There may be geographic differences in use of fluorides. However, there is no rationale for believing there to be higher rates of toothbrushing without fluoride in urban areas. Lastly, the superior oral health of the rural population may be due to diet, rather than toothbrushing. In other words, the notion that toothbrushing is more preventative of caries than diet,[38,39] does not apply. In fact, if this interpretation holds true, and assuming that oral health in early childhood tracks into adolescence, the findings of the current study show that *in spite* of lower toothbrushing prevalence among girls, a diet with less sugar results in more favourable oral health outcomes. In accordance, a recent review found a relationship between sugar consumption frequency and caries,[40] while Masson et al.[41] showed that toothbrushing with fluoride toothpaste did not overcome associations between sugar consumption and dental health treatment. The findings collectively highlight a need for new studies to consider the relative impact of diet on oral health in the wake of the "obesity epidemic".[42] It may be that previously held beliefs are now outdated, as use of fluoride toothpaste becomes the norm and dietary concerns rise, particularly for those living in a 'sweetie culture'.[43]

Childsmile[10] initially targeted children in more deprived areas, primarily in central Scotland. We may therefore see the impact of Childsmile on socioeconomic and geographic inequalities in toothbrushing in future studies. This study therefore presents area-level inequalities at the baseline. The study also highlights the importance of the school setting as a context for health promotion, particularly among boys. The findings show a clustering of toothbrushing prevalence at the school level. This is a valuable and again, pragmatic finding, suggesting more can be done at the school level to improve boys' oral health behaviour. Further research is needed to understand school differences in boys' oral health outcomes. These may be due to differences in health education within secondary schools or feeder primary schools, as toothbrushing behaviour is known to track from a young age into adulthood,[44] or may be a by-product of breakfast clubs, a provision of before-hours breakfasts offered to pupils on school premises and currently available at some secondary schools but not others; in 2010, 33% of primary and 58% of secondary schools in Scotland provided a breakfast club for pupils.[45] The study highlights the need to take account of gender differences in health behaviours within school health promotion initiatives.

Moran's I statistic was found to be positive and significant, suggesting that young people living geographically closer together had similar toothbrushing habits. This is likely due to oral health promotion initiatives, carried out in localised areas as a prelude to Childsmile, primarily in urban areas, such as the Pre-Five-Year-Old Oral Health Gain Project,[46] which ran in a deprived area in Glasgow from 1998. These may have prompted participating members of the current study cohort to establish good habits early on.

Limitations of this Study

There was a substantial amount of missing postcode information (25% of cases). We therefore chose to use multiple imputation to increase the power of the study and reduce potential response bias. Complete case analysis and imputed analysis resulted in the same conclusions, as did further adjustment for individual level familial variables, so that we are reasonably confident in the findings. However, even after imputation of missing data, the required minimum of 300 cases per sex-rurality group was not achieved for Remote Towns because the boosted sample was selected by class rather than child's residence. The impact of not achieving this sample size may have resulted in an underpowering and therefore an overly conservative test of comparison between these and urban areas within the models. Furthermore, the optimal sample size of 300 was for proportions of 65/35%. For the outcome girls’ toothbrushing, proportions were somewhere around 80%, bringing the required sample size for the same level of precision down to 205 cases per rurality.

Funding

This work was supported by NHS Health Scotland and the Ludwig Boltzmann Institute. N Nicholls and S Macdonald are funded by the Medical Research Council (MC_UU_12017/8); R Dundas is funded by the Medical Research Council (MC_UU_12017/5) and the Chief Scientist Office of the Scottish Government Health Directorates (SPHSU2).

Acknowledgements

The Health Behaviour in School-aged Children (HBSC) study is an international survey conducted in collaboration with the WHO Regional Office for Europe. The authors would like to acknowledge the HBSC international research network in 41 countries that developed the study’s research protocol.

References

1 Marinho VC, Higgins JP, Sheiham A, Logan S. Fluoride toothpastes for preventing dental caries in children and adolescents. Cochrane Database Syst Rev. 2003;(1),CD002278.

2 Löe H. Oral hygiene in the prevention of caries and periodontal disease. Int Dent J. 2000;50:129–139.

3 Maes L, Vereecken C, Vanobbergen J. Tooth brushing and social characteristics of families in 32 countries. Int Dent J. 2006;56:159-167.

4 Levin KA, Currie C. Adolescent toothbrushing and the home environment: Sociodemographic factors, family relationships and mealtime routines and disorganisation. Community Dent Oral Epidemiol. 2010;38:10-18.

5 Blair YI, McMahon AD, Macpherson LMD. Comparison and Relative Utility of Inequality Measurements: As Applied to Scotland's Child Dental Health. PLoS One. 2013;8(3):e58593.

6 Levin KA, Davies CA, Topping GVA, Assaf AV, Pitts NB. Inequalities in dental caries of 5-year old children in Scotland 1993-2003. Eur J Public Health. 2009;19:337-342.

7 Poulton R, Caspi A, Milne BJ, et al. Association between children's experience of socioeconomic disadvantage and adult health: a life-course study. Lancet 2002;360:1640-1645.

8 National Dental Inspection Programme of Scotland. Report of the 2003 Survey of P1 Children. Dundee: Scottish Dental Epidemiological Coordinating Committee; 2004.

9 Scottish Government. NHS Performance Targets. http://www.scotland.gov.uk/About/ Performance/scotPerforms/partnerstories/NHSScotlandperformance/pastHEATtargets. Published January 26, 2010. Accessed September 29, 2013.

10 NHS Scotland. Childsmile. http://www.child-smile.org.uk Published 2007. Accessed September 29, 2013.

11 Scottish Executive. An Action Plan for Improving Oral Health and Modernising NHS Dental Services in Scotland. Edinburgh: Scottish Executive, 2005.

12 Macpherson LMD, Conway DI, Goold S, et al. National Dental Inspection Programme of Scotland: Report of the 2010 Survey of P1 Children. Dundee: Scottish Dental Epidemiological Coordinating Committee, 2010.

13 Merrett MCW, Conway DI, Goold S, et al. National Dental Inspection Programme of Scotland: Report of the 2009 Survey of P7 Children. Dundee: Scottish Dental Epidemiological Coordinating Committee, 2009.

14 Campbell NC, Elliott AM, Sharp L, Ritchie LD, Cassidy J, Little J. Rural and urban differences in stage at diagnosis of colorectal and lung cancers. Br J Cancer. 2001;84:910-914.

15 Levin KA, Leyland AH. Urban/Rural Inequalities in Suicide in Scotland, 1981-1999. Soc Sci Med. 2005;60:2877-2890.

16 Levin KA, Leyland AH. Urban/Rural Inequalities in Ischaemic Heart Disease in Scotland, 1981-1999. Am J Public Health. 2006;96:145-151.

17 Weiss SJ, Ellis R, Ernst AA, Land RF, Garza A. A comparison of rural and urban ambulance crashes. Am J Emerg Med 2001;19:52-56.

18 Scottish Needs Assessment Programme. Needs Assessment Report on Remote and Rural Dentistry. Edinburgh: NHS Health Scotland, 2007.

19 NHS Scotland. Scottish Dental Practice Board Annual Report 2008/09. http://www.shsc.scot.nhs.uk/upload/file/national_committee_services/sdpb/class_3/2009_10_01_ncs_sdpb_annual_report_200809_final.pdf. Published October, 2009. Accessed September 29, 2013

20 Godden DJ, Richards HM. Health research in remote and rural Scotland: what is out there? Scott Med J 2003;48:10-12.

21 Levin KA, Davies CA, Douglas GVA, Pitts NB. Urban-rural differences in dental caries of 5-year old children in Scotland. Soc Sci Med. 2010;71:2020-2027.

22 Bishop J, Clark D, Harris V, Stockton D, Sutton M. Deprivation and urban rural measurement in ISD. Edinburgh: Information Services Division. http://www.isdscotland.org/isd/files/Measuring_deprivation_in_ISD_v3.pdf. Published 2004. Accessed September 29, 2013.

23 Currie C, Molcho M, Boyce W, Holstein B, Torsheim T, Richter M. Researching health inequalities in adolescents: The development of the Health Behaviour in School-aged Children (HBSC) Family Affluence Scale. Soc Sci Med. 2008;66:1429-36.

24 Scottish Government. Scottish Index of Multiple Deprivation 2012: A National Statistics Publication for Scotland. Edinburgh: Scottish Government. http://simd.scotland.gov.uk/publication-2012/ Published 2012. Accessed September 29, 2013

25 Scottish Government. Guidance on different analysis options for the SIMD. Edinburgh: Scottish Government, Edinburgh. http://www.scotland.gov.uk/Topics/Statistics/SIMD/SIMDguidetoanalysis Published 2012. Accessed September 29, 2013.

26 Scottish Government. Scottish Government Urban Rural Classification 2007-2008. Edinburgh: Scottish Government. http://www.scotland.gov.uk/Publications/2008/07/29152642/0 Published 2008. Accessed September 29, 2013.

27 Azur MJ, Stuart EA, Frangakis C, Leaf PJ. Multiple Imputation by Chained Equations: What is it and how does it work? Int J Methods Psychiatr Res. 2011;20:40-49.

28 Bodner TE. What improves with increased missing data imputations? Struct Equ Modeling. 2008;15:651-675.

29 Rasbash J, Steele F, Browne WJ, Goldstein H. A user's guide to MLwiN: Version 2.10. Bristol: University of Bristol, 2009.

30 Spiegelhalter DJ, Best NG, Carlin BP, van der Linde A. Bayesian measures of model complexity and fit (with discussion). J R Stat Soc Series B Stat Methodol. 2002;64:583–639.

31 Rubin D. Multiple Imputation for Nonresponse in Surveys. New York, NY: Wiley, 1997.

32 R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing, 2014.

33 Lu B, Harris P, Charlton M, Brunsdon C, Nakaya T, Gollini I. GWmodel: Geographically weighted models. 2013

34 Chaix B, Merlo J, Chauvin P. Comparison of a spatial approach with the multilevel approach for investigating place effects on health: The example of health care utilisation in France. J Epidemiol Community Health 2005;59:517-526.

35 Locker D. Deprivation and oral health: a review. Community Dent Oral Epidemiol. 2000;28(3):161-169.

36 Macintyre S, Ellaway A. Neighbourhood and health: an overview. In: I. Kawachi I, & L.F. Berkman (Eds.), Neighborhoods and health (pp. 26). New York: Oxford University Press, 2003.

37 Levin KA. Urban-rural differences in adolescent eating behaviour: A multilevel cross-sectional study of 15 year olds in Scotland. Public Health Nutr. in press.

38 Burt BA, Satishchandra P. Sugar consumption and caries risk: a systematic review. J Dent Educ. 2001;65:1017 – 1023.

39 van Loveren C, Duggal MS. The role of diet in caries prevention. Int Dent J 2001;51:399-406.

40 Anderson CA, Curzon MEJ, van Loveren C, Tatsi C, Duggal MS. Sucrose and dental caries: A review of the evidence. Obes Rev. 2009;10 (S1):41-54.

41 Masson LF, Blackburn A, Sheehy C, et al. Sugar intake and dental decay: results from a national survey of children in Scotland. Br J Nutr. 2010;104:1555-1564.

42 Lobstein T, Baur L, Uauy R. Obesity in children and young people: A crisis in public health. Obes Rev. 2004;5,(S1):4-85.

43 Smith PA, Freeman R. Living in a sweetie culture: Scottish parents' difficulties in maintaining their children's oral health. Health Educ J. 2009;68:255-265.

44 Kuusela S, Honkala E, Rimpela A. Toothbrushing frequency between the ages of 12 and 18 years – longitudinal prospective studies of Finnish adolescents. Community Dent Health. 1996;13:34-39.

45 Scottish Government. A National Statistics Publication for Scotland: School Meals In Scotland, 2010. Edinburgh: Education Analytical Services. http://www.scotland.gov.uk/Publications/2010/07/06095048/0. Published June 29, 2010. Accessed September 29, 2013.

46 Greater Glasgow Health Board. Strategic Development Programme 1996-1999. Interim report of the pre-five-year-old oral health gain project, Possilpark. Glasgow, Scotland: Greater Glasgow Health Board, 1999.

Table 1 Definition of the urban-rural classification used

Rural classification	Description[a]	% of study sample	% of Scottish population[a]
Urban	Settlements with population over 10,000 or between 3-10,000 and within a 30 minute drivetime of a settlement of 10,000 or more	58.3	77.8
Remote Towns	Settlements with population between 3-10,000 and more than 30 minutes drivetime of a settlement of 10,000 or more	9.4	4.1
Accessible Rural	Settlements with population less than 3,000 and within a 30 minutes drivetime of a settlement of 10,000 or more	14.6	11.2
Remote Rural	Settlements with population less than 3,000 and more than 30 minutes drivetime from a settlement of 10,000 or more	17.7	7.0

[a]Source: Scottish Government[26]

Table 2 Prevalence of twice-a-day toothbrushing for boys and girls by family affluence, family structure, school type and rurality, % (s.e.)

Variable	Boys	Girls
Sample Size (N)	1274	1418
Family Affluence Scale		
Low FAS	62.2 (2.7)	77.8 (1.8)
Medium FAS	62.7 (2.3)	85.5 (1.7)
High FAS	70.1 (2.6)	87.4 (1.6)
Family structure		
Both parent	67.7 (1.8)	85.7 (1.2)
Single parent	60.1 (3.3)	77.0 (2.5)
Step family	56.9 (4.5)	81.4 (3.1)
Other	50.0 (11.8)	76.0 (8.8)
School type		
Independent school	75.5 (7.7)	90.6 (4.1)
State school	64.4 (1.7)	83.1 (1.1)
Rurality		
Urban	65.6 (2.3)	84.4 (1.4)
Remote towns	60.8 (4.3)	81.1 (3.9)
Accessible rural	65.2 (3.3)	77.3 (3.2)
Remote rural	64.5 (3.5)	86.0 (2.1)
Deprivation (SIMD quintiles)		
SIMD 1 (most deprived)	56.1 (4.7)	75.0 (3.7)
SIMD 2	63.4 (4.1)	80.8 (2.5)

SIMD 3	60.8 (3.0)	79.4 (2.0)
SIMD 4	67.7 (2.4)	87.4 (1.6)
SIMD 5 (least deprived)	70.9 (3.5)	90.1 (2.2)

Clustering by school is accounted for in the calculation of SEs

Table 3 Multivariable logistic regression analysis of the association between socioeconomic and geographic variables and twice-a-day toothbrushing, under MCMC[a] modelling procedure

Fixed effects		Boys		Girls	
		OR	95% CI	OR	95% CI
Age		1.02	(0.79, 1.32)	0.74	(0.51, 1.07)
Family structure	Both parents	1		1	
	Step family	0.65	(0.43, 1.00) *	0.82	(0.52, 1.31)
	Lone parent	0.79	(0.57, 1.08)	0.66	(0.46, 0.96) *
	Other	0.46	(0.16, 1.34)	0.66	(0.24, 1.83)
Family affluence	Low FAS	1		1	
	Medium FAS	0.96	(0.71, 1.31)	1.46	(1.00, 2.13)
	High FAS	1.25	(0.90, 1.74)	1.48	(1.00, 2.19) *
School type	State	1		1	
	Independent	1.48	(0.65, 3.40)	1.13	(0.35, 3.65)
SIMD	SIMD 1	1		1	
	SIMD 2	1.27	(0.78, 2.08)	1.34	(0.80, 2.25)
	SIMD 3	1.17	(0.73, 1.89)	1.19	(0.72, 1.96)
	SIMD 4	1.43	(0.89, 2.31)	2.39	(1.37, 4.17) *
	SIMD 5	1.68	(1.03, 2.75) *	2.80	(1.51, 5.18) *
Rurality	Urban	1		1	
	Remote towns	0.90	(0.56, 1.45)	0.74	(0.42, 1.29)
	Accessible rural	0.99	(0.66, 1.46)	0.47	(0.30, 0.73) *
	Remote rural	1.04	(0.70, 1.57)	1.05	(0.64, 1.74)
Random effects					
Level 1 (child) variance[b]		1		1	
Level 2 (school) variance		0.214 (0.124)		0.076 (0.086)	
Level 3 (Education authority) variance		0.012 (0.018)		0.069 (0.076)	
$\overline{D}$ [c]		1538.5		1195.9	
p_D [d]		54.7		32.0	

DIC^e	1593.2	1227.9
DIC^e of principal components model	2265.6	1635.2

[a] via Markov chain Monte Carlo (MCMC); estimates are based on a chain of length of 50,000 following a burn-in of 15,000

[b] variance at the child level is constrained to 1

[c] $\overline{D}$ is the expectation of the deviance and is a measure of how well the model fits the data,

[d] p_D is the effective number of parameters.

[e] *DIC* is the Deviance Information Criterion; the larger this is, the worse the model fit.

*95% Confidence Intervals are above or below 0

Table 4 Multivariable logistic regression analysis of the association between socioeconomic and geographic variables and twice-a-day toothbrushing, under MCMC[a] modelling procedure, using the multiply imputed dataset

Fixed effects		Boys		Girls	
		OR	95% CI	OR	95% CI
Age		1.52	(1.10, 2.10) *	0.60	(0.39, 0.93) *
Family structure	Both parents	1		1	
	Step family	0.69	(0.49, 0.97) *	0.74	(0.50, 1.11)
	Lone parent	0.70	(0.53, 0.91) *	0.69	(0.50, 0.96) *
	Other	0.65	(0.29, 1.46)	0.60	(0.27, 1.34)
Family affluence	Low FAS	1		1	
	Medium FAS	1.03	(0.80, 1.33)	1.56	(1.12, 2.17) *
	High FAS	1.20	(0.91, 1.59)	1.55	(1.10, 2.19) *
School type	State	1		1	
	Independent	1.27	(0.64, 2.54)	0.63	(0.29, 1.40)
SIMD	SIMD 1	1		1	
	SIMD 2	1.33	(0.85, 2.08)	1.37	(0.83, 2.27)
	SIMD 3	1.16	(0.75, 1.81)	1.20	(0.74, 1.97)
	SIMD 4	1.50	(0.93, 2.41)	2.34	(1.35, 4.05) *
	SIMD 5	1.80	(1.09, 2.99) *	2.77	(1.56, 4.91) *
Rurality	Urban	1		1	
	Remote towns	0.85	(0.53, 1.36)	0.76	(0.43, 1.35)
	Accessible rural	0.88	(0.61, 1.27)	0.51	(0.34, 0.79)*
	Remote rural	1.03	(0.69, 1.53)	1.02	(0.65, 1.60)
Random effects					
Level 1 (child) variance[b]		1		1	
Level 2 (school) variance		0.145 (0.083)		0.160 (0.110)	
Level 3 (Education authority) variance		0.010 (0.013)		0.027 (0.037)	

[a] via Markov chain Monte Carlo (MCMC); estimates are based on a chain of length of 50,000 following a burn-in of 15,000

[b] variance at the child level is constrained to 1

*95% Confidence Intervals are above or below 0